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Relationship of Agro Soil Humus Content and Their Structure State.

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ABSTRACT

The non-standard relationship aspects of agrochernozem humus content and agro dark gray soil are considered with the indicators of their structural-aggregate composition - the content of boulders, dust, agronomically valuable fractions, the sizes of the aggregate average diameter. The correlations of humus content and specified parameters are weak for the entire soil profile, they are absent for organo-mineral horizons, and they are close for mineral horizons. The contradictory nature of the obtained result is explained by the influence of multidirectional factors on the studied relation nature (humus content and machining), changing the indicators of structure in opposite directions.
Keywords: Agrochernozems, agrodark-gray soil, the factors of structure formation, humus, boulders, dust, agronomically valuable fractions, the average weighted diameter of aggregates, correlation analysis

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INTRODUCTION

Belgorod region is characterized by valuable soil cover: more than 77% of its area is occupied by black soils [1]. The physical degradation of chernozems became a scientific and a practical problem, which attracts the attention of scientists. V.V. Medvedev [2] noted that the adverse changes in the structure, composition and the physical properties of soils due to intensive agricultural activities influence almost all aspects of soil functioning. The author believes that the content of agronomically useful structure is the diagnostic criterion of physical degradation.

It should be emphasized that soil aggregation is understood traditionally as the structure in Russian soil science. A soil aggregate is a unique natural formation which provides a specific form to a structural hierarchical organization and it is in the basis of all soil functions [3].

Soil structure is studied for a long time, so the factors which influence the formation of aggregates were established for a long time. These include the organic matter content, the activity of biota, the presence of clay and carbonates [4]. An important role of organic matter in a structure development is also indicated by [5; 6]. An important factor leading to the deterioration of the structure quality is the soil treatment, since the use of heavy agricultural machinery is accompanied by soil compaction phenomena and a sole shoe formation [2]. The works [7; 8] are devoted to the study of these factors influence.

Our studies include the monitoring of structural-aggregate soil composition with its long-term agricultural use. During previous studies [9] the basic laws of a studied area soil structural state were established. One of the objectives concerning a discussed study was the determination of humus impact on the indicators of structural-aggregate composition of soil, which implied the calculations of correlation closeness between the specified parameters.

METHODS

Investigations were carried out in a stationary field trial, which is the basic object of agroecological monitoring. The experience is located in Belgorod region on the territory of the site "Belgorod Agricultural Research Institute" on the slope of the river valley Eric from 1° to 5°. 6 cuts were founded, which described the soils related to the trunk of postlithogenous, the departments of humus-accumulative and texture-differentiated. They belong to the types and subtypes: typical clay-illuvial agrochernozems, migration-micellar agrochernozems and hydro metamorphized, agrodark-gray, gleysolic ones.

In order to diagnose the structural-aggregate composition Savvinov sieve method was used [10]. The content of boulder fraction, agronomically valuable aggregates, dust and an average diameter of the aggregates were determined according to its determination results. The boulder fraction (BF) includes the structural units larger than 10 mm; agronomically valuable aggregates (AVA) are the structural units with the size from 0.25 mm to 10 mm; dusty fraction (DF) - the particles the size of which makes less than 0.25 mm. According to [11], the fractions of 0.25 mm are macroaggregates and the fractions less than 0.25 mm are referred to microaggregates. An average weighted diameter of the aggregates (AWD) was calculated using the sieve analysis results according to the following formula:

$$СВД = \sum_{i=1}^{n} \overline{x_i} M_i$$

where M_i – the weight fraction of the aggregates fraction (expressed in unit fractions) with a mean diameter of x_i, n – the number of fractions. The higher AWD is - the greater large fractions expressed in a structure, the lower AWD is - then a structure is more dusty.

The methods based on direct observation of soil structural characteristics, in particular the techniques of electron microscopy or optical scanning exist for a long time [12]. However, the traditional methods of a structure study continue to be relevant and are widely used in Russian soil science.

The humus content was determined by wet ashing method in its titrimetric embodiment according to Tyurin [13]. The calculation of the correlation coefficient (r) and the evaluation of correlation tightness degree were performed on the basis of [14].

MAIN PART

Some results of the performed studies were reported by us earlier during the conference [15].

As noted in [14], among the problems solved using the statistical methods, a special place is occupied by the problems associated with the study of relationships between the variables, which can be solved using the special methods of correlation and regression analysis. Intuitively, the relation between the attributes may be expressed graphically in the form of a correlation field reflecting the set of index values for all observations in the form of points. As we know, the correlation coefficient, which reflects the relationship between random variables X and Y is the indicator of a straight connection degree between the signs. However, the test performance conditions are often complicated by the presence of minor conditions, which usually include the factors influencing one or both random variables which, accordingly, may affect the nature of the studied relation. In this regard, an important task at the interpretation of correlation analysis results is the understanding of probabilistic and statistical phenomenon nature in order not to make false conclusions.

In order to determine the closeness of correlation between the humus content and the studied parameters of a structural-aggregate composition based on the study conducted in the framework of the state order implementation issued by the Russian Federation Ministry of Education and Science and performed by Belgorod State National Research University in 2016 (project code: 185), the sampling of 26 samples in organic-mineral and mineral horizons of the studied soils was used. The limits of parameters were the following ones: humus - 0.2-5.6%, the GF - 6-78%, ACF - 2-85%, PF - 1-18%, SVD - 2-10 mm. At the same time the following types of correlations between the humus content and the studied values of the structure were set: slightly negative - with the content of boulders (r = - 0.43) and with SVD (r = - 0.55); weakly positive - with dust content (r = 0.55) and ACF (r = 0.37). Thus, it can be argued with a 95% probability degree that 18% of GF variation, 30% of SVD size variation, 30% of PF variation and 14% of ACF variation is conditioned by the variation of humus content in soil.

Figure 1 shows the correlation field of points and the trend line "humus content - SVD" as an example.

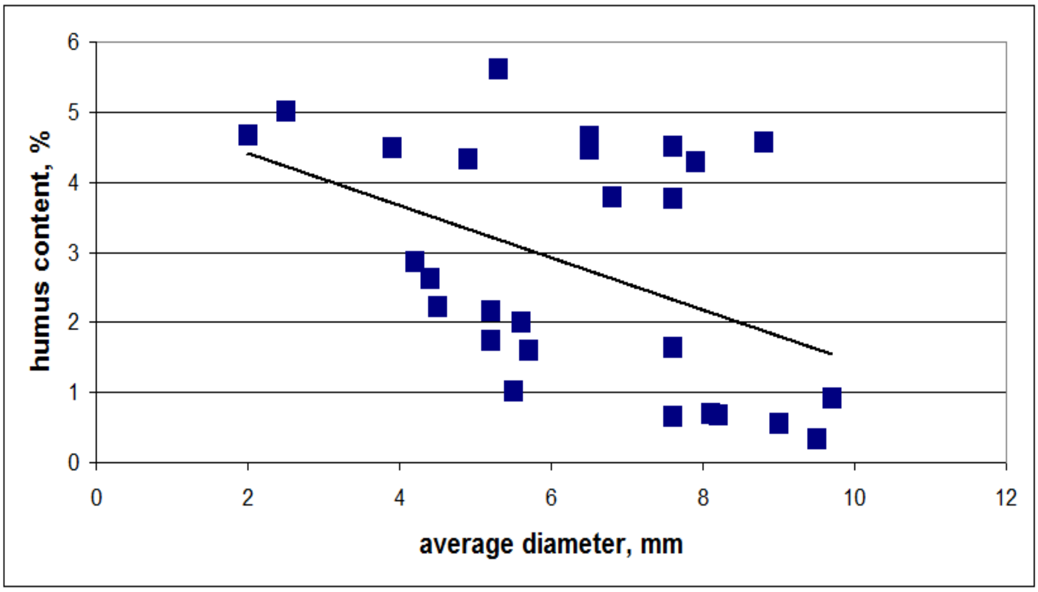

Fig. 1. The correlation field of points and the trend line of "humus content - SVD" dependence

The visual analysis of the correlation point fields and the trend lines of installed dependencies showed that in all cases, the point fields are clearly divided into two parts: the lower one (humus content up to 3.0%) with the relation trend reflecting the established pattern, and the upper one (humus content is more than

3.0%) approaching the horizontal direction without the correspondence to an intended pattern. Thus, an increased humus content to 3% affects the analyzed parameters, in particular SVD is reduced to 2 mm (these are the sizes of this valuable granular structure), and its further growth ceases to make an effect.

Figure 2 shows the correlation field of points and the trend line for the samples in which the humus content was less than 3%. Obviously, in this case, the trend line is more consistent with the set of points. This confirms the calculation of correlation coefficients for soil horizons where the humus content is less than 3%. The relationship between the humus content and the SVD became a negative and a very tight one (r = - 0.85). The relation is not proven for "humus - dust" in relation with the sample size decrease. A strong negative correlation (r = - 0.80) is established between the humus content and GF, a strong positive correlation is established for the content of humus and ACF (r = 0.81).

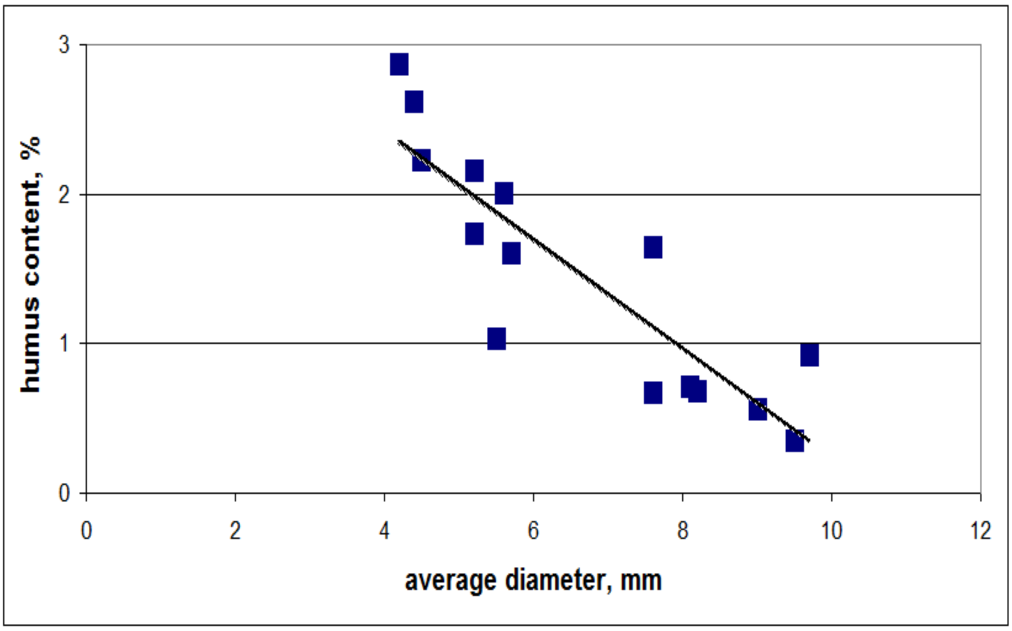

Fig. 2. Correlation field of points and the trend line of "humus content - SVD" dependence for the samples containing less than 3% of humus

The exception from the horizon analysis with the humus content of more than 3% led to the elimination of correlation field horizontal sections, to brought them closer to an elliptical shape and thus strengthened the closeness of correlations. Based on this one could conclude that the soil humus influences the structure, but only if its content is below 3%. However, this conclusion is completely contrary to existing ideas. In particular, the publications state that humus loss and the considerable enhancement of its mobility is one of the major causes for the physical degradation of arable soils as compared to a virgin land [2]; if humus content is below 3.4% a serious decline of soil quality takes place, including the deterioration of its physical properties [16]; the stability of macro-aggregates determines the organic matter content, and this feature is evident when the humus content in soil is above 5 or 6% [17].

As the stated conclusion contradicts with the ideas of humus influence on the soil structure, it is necessary to look for the violation cause of a repeatedly proven regularity, realizing the probabilistic and the statistical nature of phenomena. The thing is that the correlation ellipse may be the result of partial correlation ellipse summary, reflecting the impact of partial correlation coefficients and illustrating the secondary factors affecting a studied value [14].

We can set such factors if we consider the genetic nature of horizons, excluded from the analysis. The humus content of more than 3% was observed for all studied soils in arable and subarable horizons (plow sole), i.e. in those horizons which are subjected to the maximum human impact, transforming the soil structure. The strongest mechanical impact on the structure in the direction of its repeated compaction or spray is observed within these horizons. Thus, the factors which change the structure in opposite directions

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operate simultaneously. The result of humus impact (the structure improvement) is leveled by the mechanical action (structure deterioration), and the appearance of a studied factor influence absence on structure indicators is established.

SUMMARY

Thus, the situation analysis helps to explain the contradictory nature of the obtained data: among the secondary testing conditions the factors are presented which have an impact on one or two random variables which influence the nature of the relation under study. In this regard, the understanding of probabilistic and statistical phenomena of nature becomes an important task during the interpretation of the results in order not to make false conclusions.

CONCLUSIONS

1. The humus content of soil makes an impact on the main indicators of structural-aggregate composition: the soil profiles reveal a weak negative correlation with the content of boulders and the sizes of an aggregate average diameter and a weak positive correlation with dust content and agronomically valuable aggregates.
2. The relationship between the humus content and the indicators of structural-aggregate composition is not revealed for organic-mineral horizons of agrochernozems and agrodark-gray soils, containing more than 3% of humus, which is contrary to the existing ideas and conditioned by the influence of multidirectional factors which alter the structure: the increased humus content improves the structure, but an active mechanical impact promotes its destruction.
3. A very close negative correlation between the humus content and the weighted average diameter of aggregates, a close negative correlation between the content of humus and boulders and a close positive correlation between the content of humus and agronomically valuable aggregates are established within the mineral horizons of studied soils.
4. During the analysis of various factor impact on the soil structure it is necessary to take into account the simultaneous manifestation of conflicting trends complicating the interpretation of the results.

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